PHYSICOCHEMICAL ANALYSIS AND PURIFICATION OF DRINKING WATER FROM BOWLIS (NATURAL SPRINGS) OF DISTRICT UDHAMPUR, JAMMU AND KASHMIR (UT), INDIA

A

SYNOPSIS

Submitted to RIMT University for registration for the

Degree of Doctor of Philosophy in Chemistry

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Declaration

I hereby affirm that this synopsis, entitled "**PHYSICOCHEMICAL ANALYSIS AND PURIFICATION OF DRINKING WATER FROM BOWLIS (NATURAL SPRINGS) OF DISTRICT UDHAMPUR, JAMMU AND KASHMIR (UT), INDIA,**" being submitted for registration for the degree of Doctor of Philosophy, is my own work. It has been prepared under the supervision of Dr. Hari Singh at RIMT University, Mandi Gobindgarh, Punjab. I further affirm that it has not been submitted to any other university for registration for any degree or diploma.

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Introduction

Udhampur is the district headquarters and was named after Raja Udham Singh, the eldest son of Maharaja Gulab Singh, the founder of Dogra rule in Jammu and Kashmir. It is also known as "the land of Druva," "the land of Bowlis," and "the land of Devika."The town is said to have been built on the site of a thick forest where Udham Singh went on hunting trips until he fell in love with the area and chose it as the location for the town. Udhampur is situated between 32° 34' and 39° 30' North Latitude and 74° 16' and 75° 38' East Longitude. The elevation of Udhampur ranges from 600 to 3,000 metres above sea level. The district is located in the south-east of Jammu and Kashmir and is bordered in the west by Reasi District, in the north-east by Ramban and Doda Districts, in the south-east by Samba and Kathua Districts, and in the south-west by Jammu District. Udhampur is also known as Devika Nagri.

As of the 2011 census, Udhampur district has a total population of 5.55 lakh people (as of the 2011 census), and the district area is approximately 2380 square kilometres. The Udhampur district is brimming with natural springs known as "bowlis." The Bowlis are "natural groundwater reservoirs filled by natural springs." The Bowlis' water is hot in the winter and cold in the summer.The majority of Udhampur's population goes to these bowlis in the early morning hours for a refreshing bath and to drink water from them because it is said that the water from Bowli is good for digestion. It is also believed that people remain physically and mentally strong, and many of the skin problems are cured by drinking water from Bowlis. These Bowlis' usual accomplices are shady trees, large rocks, peepal trees, and so on, where Hindus pay their obeisance, kneel in prostration, and perform ablations. The famous Devika Temple in Udhampur Town has a cluster of eight bowlis. Each bowli is significant in its own way. Three bowlis have been designated for bathing, while others are used for temple purposes. People offer water from these bowlis to Lord Shiva, and there is a large crowd of devotees in the morning hours. On the eve of Vaisakhi, a grand fair is held at Devika Ghat for three days. This fair attracts visitors from all over the Jammu and Kashmir UT. On the days of Soma Amavasya and Vaisakhi, a large crowd gathers at this shrine from Udhampur and surrounding villages to take a dip in the Holy Devika and, after that, take a refreshing bath in the Bowlis. It is believed that bathing in the Devika and Bowlis can wash away sins, just like in mother Ganga. Some prominent bowlis (natural springs) of the Udhampur district being used by the public as drinking water sources are:

1. Billan Bowli: This bowli is located behind the Head Post Office in Udhampur. In front of this bowli, there is a Shiva Temple. This bowli's water is crystal clear and beneficial for good health. The water from this spring is used for drinking by the people who live nearby. This residential area is also known as Billan Bowli Mohalla.

2. Kallar Bowli : This bowli is located on Dhar Road near Kallar on the western side of Udhampur. This bowli is adjacent to a Shiva Temple. Lush green water is oozing from the hill and is being stored in a pond built by the residents of this neighbourhood in 1953.

3. Khartairi Bowli: This bowli is located on the Udhampur bypass NH-44 national highway, near Sangoor and Barrian Mohalla. There are two bowlis, one of which is covered and the other is open. The water is drawn from the hillside by the open one. Near this bowli, there is a Shiva temple and a Chinar tree.

4. Mian Bagh Bowli: This bowli is located on the left side of Air Force Road, close to Broadway Plaza, and there is an ancient Shiva temple in the complex of this bowli.

5. Ratairi Bowli: This bowli is located near the District Food and Supply Store in Udhampur.

6. Saaken Bowli: It is located near Udhampur Railway Station and it is named Saken Bowli, which in Dogri means the relationship between two wives of a person. The origin of this bowli is an outlet from the bottom of the hill, and the water is diverted into two ponds equally.

7. Sansu Bowli: This bowli is located at Supply Morh Udhampur on Panchari Road, and there is an ancient Shiva Temple on the side of this bowli.

8. Mongu Di Bowli: This bowlli is located near Devika Ghat and it is named Mongu Di Bowli the Bowli after the name of a pious person named Mangu who constructed it in the year 1941.

9. Londana Bowli: This bowlli is located near the shrine of Baba Londana near the village of Battal Ballian in Udhampur, and it is believed that people suffering from skin ailments are cured after having a dip in this bowli (spring) due to the shrine Shakti of Baba Londana.

10. Niki Bowli (Baan). It is situated in Jaganoo Panchayat of Udhampur District.

11.Morh ala Soola Bowli (Baan). It is situated at Jaganoo Morh near MES station Dhar Road in Udhampur.

12. Naal Bowli: It is situated at W.No. 20, Sial Salan, near NH-44, Udhampur.

13. Gency di Baan(Bowli). It is situated near the main Ghordi Block in Ramnagar Tehsil, District Udhampur. It is beautifully surrounded by peepal trees (Barh de Bute) and an annual Dangal is also conducted annually at this place in the month of June.

14. Clean Bowli: It is situated near Green Park Dhaba, Officer Mess Road, and Dhar Road in Udhampur.

15. Laarah Soo Bowli: It is situated in W.No.1 of Panchayat Laarh in Tehsil Ramnagar, District Udhampur.

16. Sapar Bowli: It is situated at Birwan Bridge near Malahar, NH-44 Bye Pass, Tehsil & District Udhampur.

17. Pittan Barh Bowli: This bowli is situated in the Pittan Barh area of Udhampur near the shores of the Devika River. The water from this bowli is considered pure and is used for drinking and bathing purposes by the locals.

18. Aerly Baan (Bowli): It is situated in village Meer, tehsil Panchari, in the district of Udhampur, and there is an ancient temple near this bowli.

19. Panchari Bowli: It is situated near Tehsil Headquarter Panchari, a beautiful hill station in the District of Udhampur.

20. Lander Bowli: It is situated at Lander Panchayat, Tehsil Panchari, District Udhampur, and there is an ancient Narsingh Mandir near this bowli.

21. Snara Bowli: It is situated near Moungri Tehsil Headquarter in the district of Udhampur.

22. Ursala Paani Bowli: It is situated in the village of Basnote, Tehsil Moungri, in the district of Udhampur.

23. Talia Bowli: It is situated in Sarpati Basnote village, tehsil Moungri, district Udhampur.

24. Shiv Gali Baan: It is situated near Shiv Gali Top (one of the beautiful tourist places), Tehsil Basantgarh, District Udhampur.

25. Paap Naashni Bowli (also known as Paap Naathen di Baan): It is situated near the popular Sudh Mahadev Lord Shiva Temple, Tehsil Chenani, District Udhampur. Every year at this place, the Ashad Purnima festival is also organised. It is believed that devotees visit this natural spring to absolve their sins.

26. Raanki Bowli: It is located in the village of Dudu, Tehsil Latti-Marothi, District of Udhampur.

27. Shalu Bowli: It is situated in the village of Dudu, Tehsil Latti-Marothi, District Udhampur. This is a popular platform for Sindu Darshan.

28. Sral Bowli: It is situated in the Thildu village in Tehsil Latti-Marothi, District Udhampur.

29. Mat Bowli: It is situated at Manwal on the Dhar Road in Tehsil Majalta, District Udhampur.

30. Gaya Bonta Bowli: It is situated near the bus stand in Manwal, Tehsil Majalta, District Udhampur.

The architecture of all these bowlis strongly depicts the rich culture and heritage of Jammu's Dogra dynasty. These bowlis also represent the rituals and beliefs of the Dogrsa. During the Dogra festivals like Bacch Dua, observed by the mothers for the long life of their sons, they offer prayers at the Bowlis. After Navratras as well, the women of Udhampur gather at these bowlis to immerse the Saakh in the sacred water of the natural springs.

It is believed that in a 4-5 km land stretch extending from Shakti Nagar to the Mian Bagh area in Udhampur, there were 108 bowlis. Due to increasing human activities, particularly construction of houses, roads, etc., around the natural springs (Bowlis), their number has been reduced to 40. In the Billan Bowli area alone, it is said that there was a cluster of around 20 Bowlis, but their number has also been reduced to almost half the original figure.

Statement of the Research Problem

Water is the most significant factor in sculpting the terrain and regulating the climate. It is one of the most essential molecules that has had a significant impact on human life. Water is the most abundant and extensively distributed substance in nature. Surface water in lakes, rain, and streams, as well as ground water in wells, boreholes, and springs (bowlis), are all examples of water. There are 1400 billion litres of water in total, but most of it is not used for drinking because 97 percent of it is sea water and only 3% is fresh water, of which 2% is glacier water. Only 1% of the total water is potable, and more is used for irrigation than for drinking, sanitation, and all other uses (WHO, 2004) [1]. In the Indian Himalayan Mountains, springs are the primary source of freshwater for drinking and other domestic purposes. People in rural areas, in particular, rely on spring water for drinking [2]. In many parts of the Udhampur District, the natural springs, locally known as "Bowlis" also act as a crucial source of irrigation water. When water pressure creates a natural flow of groundwater on to the earth's surface, it is known as a natural spring (Bowli). Water pours out naturally to the surface through fissures and tunnels inside the aquifer, and this water flows out naturally at places called springs (Bowlis). The water quality of Bowlis (natural springs) in Udhampur district is also getting degraded due to agriculture, use of fertilizers, manures, and pesticides, animal husbandry activities, inefficient irrigation practices, deforestation, aquaculture, pollution due to industrial effluents and domestic sewage, mining, and recreational activities. The rate of recharging of a natural spring (bowli) is steadily decreasing, resulting in a drop in the water table. As water has a variety of effects on people's health, the importance of drinking quality water cannot be overstated. Researchers are working worldwide on water quality assessment, but no systematic study has been done to assess the drinking water quality of bowlis (natural springs) covering all the tehsils in Udhampur District (J&K UT).

So, the present research problem has been selected to assess and purify the drinking water from Bowlis (natural springs) covering all the tehsils of Udhampur District (J & K UT). The various physico-chemical parameters like temperature, colour, taste, turbidity, pH, conductivity, total dissolved solids, hardness, calcium, magnesium, chloride, sulphate, fluoride, alkalinity, nitrate, phosphate, toxic metals (Cu, Cr, Cd, Zn, Pb, Hg, Fe, Mn, etc.), organic impurities (phenols, dyes, oil and grease, pesticides, etc.), BOD, and COD are to be included in this study.

The present study will also include the possible purification methods to improve the quality of Bowli's water for drinking purposes.

Review of Literature and Research Gap

Water connects every aspect of life. It is the most important component of all living things. Water, for example, makes up roughly two-thirds of the human body's weight [3]. Around 780 million people do not have access to safe drinking water, and 2.5 billion do not have proper sanitation. Each year, approximately 4 million people die as a result of water-borne diseases and disasters [4]. Drinking unsafe, contaminated water has a slew of negative impacts that aren't entirely known. As per the World Health Organization (WHO), drinking contaminated water is one of the biggest causes of diarrheal illnesses, which are the second greatest cause of child mortality, killing around 760,000 children under the age of five each year. As a result, the WHO has recognised a lack of access to safe drinking water as the single most important factor affecting the general health and well-being of people in developing nations [5]. Overall, providing safe drinking water can help to reduce or eliminate unnecessary fatalities (as a result of water-borne diseases) while also improving the quality of life for low-income households all over the world [6]. The availability of safe drinking water and sanitation is a global issue. Taste, colour, aroma, turbidity, and organic and inorganic matters all affect water quality and fitness for usage [7]. Contaminants in water can have an impact on its quality and, as a result, on human health. Inorganic and organic materials, radionuclides, disinfectants, and microbes are all types of pollutants that contaminate water [8]. In general, inorganic chemicals make up a larger percentage of pollutants in drinking water than organic compounds [9].When compared to other ions, Ca^{2+}, Mg^{2+}, Na^{+}, K^{+}, Cl^{-}, F^{-}, NO^{2-}, NO^{3-}, SO_4^{2-}, HCO_3^{-}, $CO_3^{2-}$are typically present in water and are responsible for its saltiness [10]. Water contamination due to the presence of heavy metals is a serious problem all over the world [11]. In India and internationally, a great deal of effort has gone into evaluating the physico-chemical properties of various drinking water sources. A brief account of work done at the international level is discussed as below:

Barakat et al. (2018) [12] conducted a study to examine the water quality of Karsatsprings located in the Piedmont of Béni-Mellal Atlas (Morocco) for drinking purposes. The physicochemical and microbial characteristics of water samples from seven Moroccan springs were investigated. All of the sampling springs' water quality ranged from medium to

'good' for drinking purposes. Prior to being used for drinking, environmental considerations such as systematic quality control and adequate treatment are required.

Rim-Rukeh (2013) [13] used the physicochemical and biological characteristics of surface water samples to investigate the surface water quality of some stagnant water bodies (ponds and lakes) in Nigeria's Niger Delta region.Results on the quality of the water using the Malaysian Water Quality Index (WQI) showed that the used pond and Obi Lake belong to Class II with values of 75.24 and 76.73, respectively. They found that the WQI of Ogutalake, Omuku pond, Ugheghe pond, Karabodone lake, and Abua lake were 67.46, 65.64, 65.87, 50.77, and 67.01, respectively, and belong to class III. The WQI of Ikaramalake, Tenmako lake, and Adiegbe lake were 43.38, 37.60, and 41.40, respectively, and belong to class IV and were described as fair.

In order to promote access to safe drinking water, **Bwire et al. (2020) [14]** investigated the physicochemical characteristics of surface and spring water in cholera-endemic communities in Uganda. The study's findings revealed that surface water and springs in the study area were unfit for human consumption and had favourable physicochemical parameters for the spread of waterborne diseases such as cholera.

Omara et al. (2019) [15] evaluated the bacteriological and physical profiles of water from three springs in the Kyambogo University vicinity. Two weekly water samples from each spring for five weeks were obtained and analyzed. The physicochemical and biological parameters like temperature, pH, turbidity, electrical conductivity, chlorides, sulphates, total coliform and E. coli counts of the samples were determined. The mean temperatures of the water samples from Katalina, Airport Spring 1, and Airport Spring 2 were 20.53℃ ± 1.2℃, 21.53℃ ± 0.60℃ and 20.33℃ ± 1.62℃. The corresponding statistical mean pH values were 5.33 ± 0.25, 6.30 ± 0.10 and 7.10 ± 0.46. All the springs were found to be microbiologically contaminated with total coliforms and E. coli above WHO permissible limits. They found that the water from the sampled springs was not safe for drinking.

Daghara et al. [16] investigated the microbiological and physiochemical quality parameters of drinking water from springs in all of the Palestinian Water Authority's licenced springs in the West Bank. A total of 127 samples were collected from 300 springs. Each sample's chemical, physical, and biological parameters were measured. Then, using national and international quality standards, the obtained characteristics were evaluated (PSI and WHO). Temperature, pH, EC, total hardness, nitrate, sodium ions, total chlorine, residual chlorine, turbidity, and total and

faecal coliforms were among the parameters studied**.** Most of the investigated physical and chemical parameters were within acceptable standard limits. However, the turbidity and chloride and nitrate concentrations exceeded standard limits.

Tankersley et al. (2020) [17] studied the zeolite water purification filtration in the undisturbed sediments of the Corriental reservoir, a drinking water source at the Maya city of Tikal, during the Late Preclassic to Late Classic cultural periods. X-ray diffraction analysis (XRD) and six AMS radiocarbon ages showed that between 2185 and 965 cal yr B.P., the drinking water in the Corriental reservoir was filtered through a mixture of zeolite and coarse, sand-sized crystalline quartz. Non-toxic, three-dimensionally porous, crystalline, hydrated aluminosilicate with natural adsorbent and ion exchange properties, which removes harmful microbes as well as dispersed insoluble and soluble toxins from drinking water. The occurrence of zeolite in Corriental reservoir sediments expands our understanding of the earliest history of water purification and the long-term sustainability of an ancient Maya city.

A lot of work has been done at the national level. A brief account of the same is given as under:

Patni et al. (2021) [18] investigated the seasonal variation of physico-chemical parameters in natural spring water sources in Pithoragarh, Uttarakhand, India. During the study, sixteen parameters were investigated for the pre-monsoon and post-monsoon seasons. Pre-monsoon total dissolved solids were found to range from 315 to 729 mg/L, while post-monsoon total dissolved solids were found to range from 245 to 704 mg/L. Two samples were found to have high total hardness and total alkalinity. The water quality index was calculated to see if drinking water samples were safe, and its values ranged from 35.71 to 74.39 during the pre-monsoon season and 31.66 to 72.60 during the post-monsoon.

Laser fluorometry was used by **Patni et al. (2020)** [**19**] to investigate the seasonal variation of uranium (U) concentration levels in natural drinking water. A total of 23 drinking water samples were collected from natural springs, along with seventeen physicochemical parameters, including the estimation of six heavy metals and uranium. The results showed that the average TDS value was 204.65 mg/L during the pre-monsoon season and 213.82 mg/L during the post-monsoon season, and that the uranium concentration in drinking water samples ranged from 0.10–9.90 µg L^{-1} during the pre-monsoon and 0.10–8.32 µg L^{-1} during the post-

monsoon seasons. The study found that none of the samples exceeded the World Health Organization's guideline values for uranium concentration in drinking water (30 µg L−1), indicating that the sources are safe in terms of uranium concentration.

Singh et al. (2020) [**20**] assessed the quality of several sources of water by measuring temperature, pH, conductivity, total dissolved solids (TDS), dissolved oxygen (DO), free carbon dioxide (free CO_2), alkalinity, hardness, calcium, phosphate, nitrate, chloride, and coliform count. All of these variables were examined using the American Public Health Association's standard approach. In addition, a water quality index was calculated using seven parameters (pH, TDS, alkalinity, hardness, calcium, nitrates, and chloride) to assess the overall drinking water status of sampling sites. A health survey of the village's residents was conducted.

For one year, from December 2010 to November 2011, **Khan et al. (2012) [21]** studied and analysed physicochemical parameters to better understand the quality of Triveni Lake. Water temperature, air temperature, pH, humidity, conductivity, free CO_2, total solid, dissolved oxygen, total alkalinity, total hardness, $CaCO_3$, Ca^{2+}, and Mg^{2+} were among the physicochemical parameters investigated. The findings revealed that some physicochemical parameters showed significant seasonal variation, while the majority of the parameters were within normal limits, indicating that the lake water was of higher quality. According to his report, the water is best for drinking in the winter and summer seasons.

Jasmin et al. (2014) [22] investigated and analysed the spatial and temporal variations in physicochemical quality parameters of groundwater in the Araniar River Basin, India, to determine its suitability for drinking through the development of drinking water quality index (DWQI) maps for the post-and pre-monsoon periods in order to determine its suitability for drinking. The suitability for drinking was determined by comparing the physicochemical parameters of groundwater in the study area to World Health Organization (WHO) and Bureau of Indian Standards (BIS) drinking water standards (BIS). During the post-and pre-monsoon seasons, the basin's groundwater was slightly alkaline. In both seasons, the levels of calcium (Ca^{2+}), magnesium (Mg^{2+}), sulphate (SO_4^{2-}), nitrate (NO_3^-), and fluoride (F^-) were within acceptable limits.

Singh et al. (2018) [23] published an article that listed different types of adsorbents and reviewed the state-of-the-art of the removal of different pollutants from water. They discussed the sources of contamination and toxicities of pollutants. Adsorption mechanisms responsible for

pollutants' removal by different adsorbents have been reviewed. They also pointed out the advantages and drawbacks of adsorbents and the future research needs in the area of water purification by adsorbents.

At the regional level (J & K UT), a few of the studies reported are discussed as under:

Anuradha et al. (2021) [24] investigated the drinking water quality of some of the springs in Lansi village of Udhampur district (J & K UT) by applying the Water Quality Index (WQI) and comparing various physical and chemical parameters to Indian and WHO drinking water standards. For the duration of the study, two springs (S1 and S2) in Lansi village that are used for drinking water were chosen. Water samples from springs were collected and analysed for pH, total dissolved solids (TDS), total hardness, alkalinity, electrical conductivity (EC), bicarbonate (HCO_3^-), calcium (Ca^{2+}), potassium (K^+), magnesium (Mg^{2+}), sodium (Na^+), and sulphate ($SO4^{2-}$), among other physicochemical parameters. The WQI value for S1 was 35.99 which falls under the "excellent" water quality category and for the S2, WQI was 88.19 which comes under good water quality. In general, water from both springs was found to be suitable for drinking purposes.

Pragya Khana (2014) [25] investigated the quality of ground water in some springs (Bowlis) in Udhampur (J & K) to determine its suitability for domestic use. Among the parameters investigated were pH, electrical conductivity (EC), carbonate (CO32-), bicarbonate (HCO3-), chloride (Cl-), sulphate (SO42-), nitrate (NO3-), fluoride (F-), calcium (Ca2+), magnesium (Mg2+), sodium (Na+), potassium (K+), iron (Fe), and total hardness (TH).During the pre-monsoon period, water samples were collected from 17 different springs (Bowlis) (Mar. 2014 to May 2014). The results were compared to drinking water standard values established by IS: 10500, BIS, and WHO. To statistically analyse the data, the statistical metrics Mean, Range, Standard deviation, coefficient of variation, correlation coefficient, Kurtosis, and Skewness were calculated methodically for each parameter. Single factor Anova tables, Piper Diagrams, and Schoeller graphs were created to represent the main findings. Furthermore, an account has been prepared to analyse factors such as anions (meq/l), cations (meq/l), calculated TDS (mg/l), dissolved minerals (mg/l) such as halite (NaCl), sylvite (KCl), carbonate ($CaCO_3$), dolomite [$CaMg(CO_3)_2$], anhydrite ($CaSO_4$), permanent hardness, and temporary hardness.

Pallavi et al. (2018) [26] conducted a study on the physicochemical analysis of 10 springs water in the Doda district (J & K), namely Nag, Nagini, Shabi, Malhota, Bhagi, Kawani, Dhari,

and Sulie.These spring water samples were collected on a monthly basis from December 2015 to June 2016. Temperature, pH, electrical conductivity (EC), TDS, turbidity, DO, FCO2, total alkalinity, total hardness, calcium and magnesium hardness were all examined.The values of the parameters were determined to be within the safe limit (WHO), indicating that some sources of spring water are safe to drink and use in the home for the residents of the region.

Kumar et al. (2018) [27] measured Radon concentration in water samples of 41 different locations from district Udhampur (J&K) by using RAD7 and Smart RnDuo monitor and found that variation of radon concentration in water ranged from 1.44 ± 0.31 to 63.64 ± 2.88 Bq L^{-1}, with a mean value of 28.73 Bq L^{-1} using RAD7 and 0.64 ± 0.28 to 52.65 ± 2.50 Bq L^{-1}, with a mean value of 20.30 Bq L^{-1} using Smart RnDuo monitor, respectively. About 17.07 percent of the water samples analysed had elevated radon concentrations over the United Nations Scientific Committee on the Effects of Atomic Radiations' recommended reference level (UNSCEAR). The mean yearly effective dose of these samples was assessed, and 78.95 percent of them were found to be within the World Health Organization's (WHO) and European Council's (EC) acceptable limits (EU). The results of the investigation showed that the values produced using the two methods were very similar. A microwave plasma atomic emission spectrometer was used to measure heavy metals (Zn, Cd, Fe, Cu, Ni, As, Hg, Co, Pb, and Cr) in water samples, as well as their relationship with radon level.

Slathia et al. (2014) [28] studied anthropogenic pressures on the water quality of Devika Stream in Udhampur City (J&K) and evaluated some physicochemical parameters by standard procedures. It was found that most of the parameters were more than the desirable limits set by BIS (1991), WHO (2008), and CPCB standards, and it was also concluded that they may exceed the permissible limits in the future if proper precautions are not taken.

Since then, there has been no scientific investigation into the physicochemical parameters and improvement of drinking water quality of the bowlis (natural springs) of District Udhampur (J& K UT). So the present attempt has been undertaken to define the maximum physical and chemical parameters of water samples from bowlis (natural springs) used for drinking that influence the truly acceptable quality of drinking water as per the desirable limits set by BIS (1991), WHO (2008) and the latest CPCB standards.

Need and Objectives of the Study

The majority of the people in the Udhampur district get their drinking water from bowlis (natural springs). As a result, the following objectives have been formulated to assess the quality of drinking water in the Udhampur district areas:

1. To assess the drinking water quality of bowlis (natural springs) with respect to physico-chemical parameters and metallic constituents.
2. To assess the drinking water quality of bowlis (natural springs) with respect to BOD, COD, and organic impurities (phenols, dyes, oil and grease, pesticides, etc.,)
3. To study the impact of seasonal variation on physicochemical parameters.
4. To do a comparative analysis of the Water Quality Index (WQI) with reference to drinking water standards.
5. To improve the drinking water quality of bowlis (natural springs) by appropriate purification methods.

Scope of the Study

The Jal Shakti Abhiyan is a campaign for water conservation and water security in India. It is a collaborative effort of various ministries of the government of India and state/UT governments. The campaign was launched by the Department of Drinking Water and Sanitation in 2019. **Prime Minister Narendra Modi** recently launched a newly designed Jal Jeevan Mission (JJM) mobile application on **October 2, 2021, Gandhi Jayanti.** The Department of Drinking Water and Sanitation's mission is to assist, empower, and facilitate States and Uts in developing a participatory rural water supply strategy to ensure long-term potable drinking water security for every rural household and public institution, such as GP buildings, schools, Anganwadi centers, health and wellness centers, and so on.So, the proposed research work has a wider scope with reference to "Conservation of Water, minimising waste and ensuring its more equitable distribution both across and within Udhampur District through integrated water resources development and management."

Materials and Methods

Study Area

The samples of water from Bowlis will be collected from different places in Udhampur district (J&K UT) in winter, pre-monsoon, and post-monsoon seasons.

Water Sample Collection

Water samples from Bowlis will be collected in fresh polyethylene bottles of 2 litre capacity without any air bubbles as per standard procedure for sampling preservation and analysis of parameters (APHA 2012). The water samples will be collected during the winter, pre-monsoon, and post-monsoon seasons to check the seasonal variation in the drinking water quality. The water samples will be analysed for different physical and chemical parameters by using suitable and highly recommended experimental methods.

Study Parameters

The water samples will be analysed for different physico-chemical parameters like temperature, colour, taste, turbidity, pH, conductivity, total dissolved solids, hardness, calcium, magnesium, chloride, sulphate, fluoride, alkalinity, nitrate, phosphate, toxic metals (Cu, Cr, Cd, Zn, Pb, Hg, Fe, Mn, etc.), organic impurities (phenols, dyes, oil and grease, pesticides, etc.), BOD, and COD by using suitable and highly recommended experimental methods to check the reference levels as given by BIS & WHO.

Table 1: List of Physico-chemical parameters and their experimental methods

S.No.	Parameter	Experimental/Analytical Method
1.	Temperature	Thermometric Method
2.	Colour	Spectrophotometric Method
3.	Taste	Checking limit of Fe & Mn by Atomic Absorption Spectrophotometry/ Colorimetric method
4.	Turbidity	Turbidity Meter (Nepheloturbidimetry)
5.	pH	pH Meter/Electronic Method
6.	Conductivity	Conductivity Meter Method

7.	Total Dissolved Solids(TDS)	Gravimetric Method
8.	Total Suspended Solids(TSS)	Filtration Method
9.	Total Hardness	EDTA Method
10.	Calcium & Magnesium	Titrimetry (titration against EDTA solution)
11.	Alkalinity	Titrimetric Method
12.	Chloride	Argentometric Method
13.	Boron, Fluoride, Nitrate & Nitrite	Colorimetric Method
14.	Sulphate & Phosphate	Gravimetric Method
15.	Aluminum, Copper, Zinc, Iron, Chromium, Cadimum, Silver, Lead, Arsenic, Manganese & Mercury	Atomic Absorption Spectrophotometric Method
16.	Dissolved Oxygen(DO)	Winkler's Method
17.	Biological Oxygen Demand (BOD)	3-Day BOD Test(APHA 22nd Ed.-5210B) /Titrimetric Method
18.	Chemical Oxygen Demand (COD)	Reflux Digestion Method
19.	Organic Impurities (phenols, dyes, oil and greases, pesticides, etc.,)	UV-Vis Spectrophotometric Method/HPLC

Water Quality Index

The Water quality index (WQI) is an important and unique tool to illustrate the overall water quality status and is helpful for the selection of suitable treatment techniques to meet the concerned issues [27]. The WQI is described as an index that reflects the combined impact of several water quality parameters that are considered and taken into account while calculating the water quality index. The Water Quality Index (WQI) shall be calculated by using the following equation:

$$WQI = \sum qn\ Wn / \sum Wn$$

Where; qn = Quality rating of nth water quality parameter;

Wn= Unit weight of nth water quality parameter.

The WQI ranges, the corresponding water quality condition, and their possible uses are summarized in the following table:

Table 2: Water Quality Index (WQI) Values and their possible Usages [28].

S.No.	Water Quality Index (WQI) Value	Quality Status	Possible Usages
1.	0-25	Excellent water quality	Drinking
2.	26-50	Good water quality	Domestic, Irrigation and Industrial
3.	51-75	Fair water quality	Irrigation and Industrial
4.	76-100	Poor water quality	Irrigation
5.	101-150	Very Poor water quality	Restricted use for Irrigation
6.	Greater than 50	Extremely Poor water quality	Unfit for drinking & proper treatment is required before use

Tentative Chapter Plan

Thesis will comprise of five chapters:

Chapter-I: Introduction

In this chapter, various details, including the importance of water, its availability, its correlation with health and population growth, water quality with reference to physiochemical properties as per the desirable limits set by BIS (1991), WHO (2008), and CPCB standards, drinking water sources, their pollution problems, bowlis (natural springs), their origin, religious and cultural importance, and benefits related to health will be discussed. Besides, the statement of the research problem will also be discussed.

Chapter-II: Review of Literature

In this chapter, a detailed review of the published literature on physicochemical parameters of water and other investigations into drinking water sources, including bowlis, undertaken at

regional, national, and worldwide levels will be written. The research gap, need, and goals of the study, as well as its scope, will all be discussed in this chapter.

Chapter-III: Materials and Methods

In this chapter, the methodology adopted will be discussed to investigate the quality parameters of water as per BIS, WHO, MICR, APHA, and other established procedures. The sampling techniques, sampling stations' selection, and criteria for the selection of sampling stations will also be discussed.

Chapter-IV: Results and Discussion

The results will be summarised in this chapter in a brief and concise manner. It also outlines the breadth of various methods that might be used to conserve drinking water sources without polluting them. Based on the findings, some potential scopes will also be discussed for the removal of impurities and heavy metals using the adsorption process by adding microporous and natural adsorbents, e.g., activated carbon, silica gels, alumina, Clinoptilolite zeolite, pea nut husks, coconut shells, charcoal, etc. in the Udhampur area as a case study..

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